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HYDROMETEOR CLASSIFICATION FROM POLARIMETRIC RADAR MEASUREMENTS DURING STEPS

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ABSTRACT

A fuzzy logic system for classification of hydrometeor type based on polarimetric radar measurements collected during the STEPS (Severe Thunderstorm Electrification and Precipitation Study) field experiment is described in this paper. During STEPS, T-28 aircraft collected in-situ samples of hydrometeors and those measurements are used in the validation of the hydrometeor classification algorithm. In addition to the application of hydrometeor classification scheme, the sensitivity of the inferences to various polarimetric radar measurements is also studied, with the objective of obtaining the best possible classification. Results from STEPS are used to evaluate the inferences with in-situ obsevations. classification.

1. INTRODUCTION

Polarimetric radar measurements provide information (shapes, size distributions, fall behaviors) on hydrometeors and it is useful to integrate such data in order to infer hydrometeor type. The purpose of this paper is to obtain good fuzzy classification using the sensitivity of polarimetic measurements to hydrometeors. Fuzzy classification using polarimetric data is an efficient mechanism to discriminate hydrometeor types (Liu and Chandrasekar, 2000; Vivekanandan et al. 1999; Straka et al. 2000). But when the radar measurements are contaminated, the classifier output will be also erroneous. In this paper, a fuzzy classifier with parameter sensitivity to hydrometeor type is studied.

This paper covers two prime objectives: 1) Implement the sensitivity of parameters to classify hydrometeors in the hydrometeor classification 2) Comparision with T-28 in-situ observations.

2. FUZZY CLASSIFICATION ALGORITHIM USING SENSITIVITY OF THE INFERENCES

LDR (linear depolarization ratio) can be contaminated by noise more easily than other polarimetric parameters, because the cross-polar signal is typically weak. The lowest possible LDR is about -34 dB for the CSU-CHILL radar (Hubbert et al. 1998). Therefore, the hydrometeor classifier can be used in a two step approach. When LDR is not contaminated the classifier uses six parameters (Z_h, Z_{dr}, K_{dp}, LDR, ρ_{hv}, and height - Fig.1). Second, when LDR is significantly contaminated by noise (crosspolar signal-to-noise ratio is below 10 dB), the classifier uses five parameters (Z_h, Z_{dr}, K_{dp}, ρ_{hv}, height - Fig.2).

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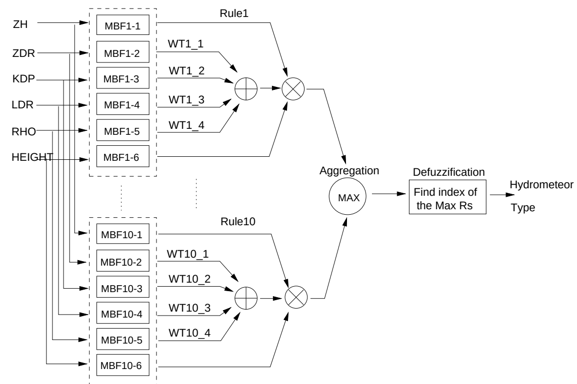

Fig. 1. Block diagram of the fuzzy classifier for good L_{dr}

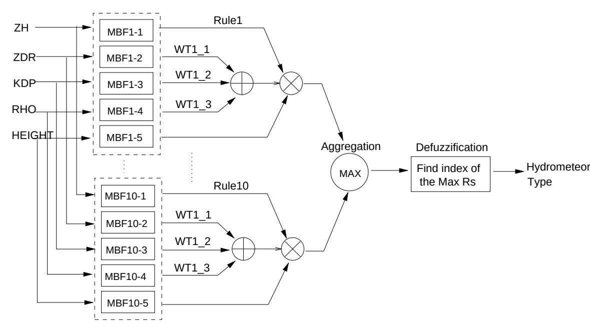

Fig. 2. Block diagram of the fuzzy classifier for bad L_{dr}

The sensitivity of the measurements to classification of hydrometeors is different. When discriminating rain from rain/hail mixture, Z_{dr} and K_{dp} may play a more important role (Balakrishnan et al. 1990). LDR is more sensitive to wet snow and hail, and ρ_{hv} may classify wet snow and rain/hail mixture (Abou et al, 2000). Therefore, a sensitivity factor can be used in a fuzzy logic classifier. The sensitivity factor is shown in Table 1 for the case of good LDR, while for noise- contaminated LDR, the sensitivity factors are set to 0.8, 0.8, and 0.4 for Z_{dr}, K_{dp}, and ρ_{hv}, respectively.

Class	Z_{dr}	K_{dp}	L_{dr}	ρ_{hv}
Drizzle	0.7	0.6	0.5	0.2
Rain	0.7	0.6	0.5	0.2
H.Rain	0.7	0.6	0.5	0.2
D.Snow	0.6	0.5	0.7	0.2
Crystal	0.6	0.5	0.7	0.2
W.Snow	0.6	0.45	0.7	0.35
G/S. Hail	0.7	0.6	0.5	0.2
W.G/S.Hail	0.6	0.6	0.6	0.2
Hail	0.6	0.6	0.5	0.3
Rain+Hail	0.6	0.6	0.5	0.3

TABLE 1
Sensitivity factors of the inferences to various polarimetric radar measurements

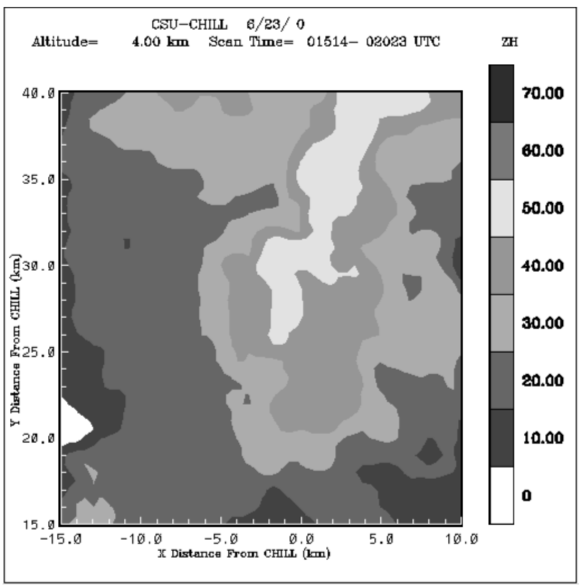

Fig. 3. Radar measurement of Z_h ahown as a CAPPI at 4 Km

3. PERFORMANCE EVALUATION

The performance of the hydrometeor classifier is evaluated by comparing the results with T-28 aircraft 2DC, HVPS and hailspectrometer data for June 22 2000 case study. The flight through the storm was at a constant altitude of 4 km above ground. The reflectivity and the hydrometeor classification result is shown in Fig.3 and Fig.4, where the solid line is the T-28 aircraft track. Classification along the T-28 aircraft track (from 241500 to 242000 UTC) is shown in Fig.5. The T-28 aircraft 2DC image data is shown in Fig.6. Fig.7 shows the hail total counts from hail spectrometer. The classifier results for region A (x=-5.99Km, y=16.31 Km),region B (x=-3.85 Km, y=22.12 Km), region C (x=-2.76

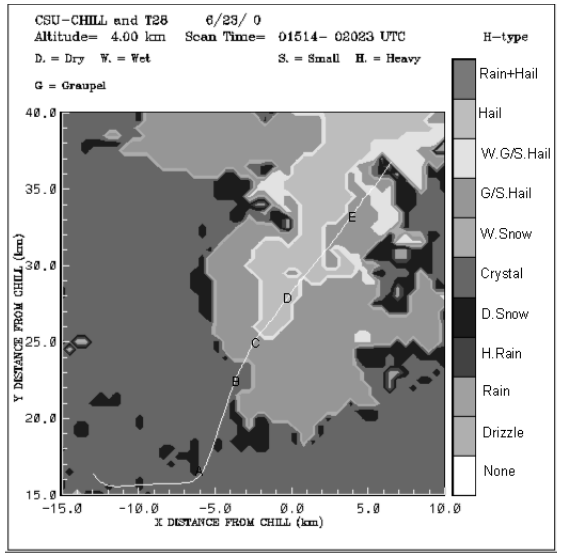

Fig. 4. Fuzzy hydrometeor classification results for the storm on June 22, 2000

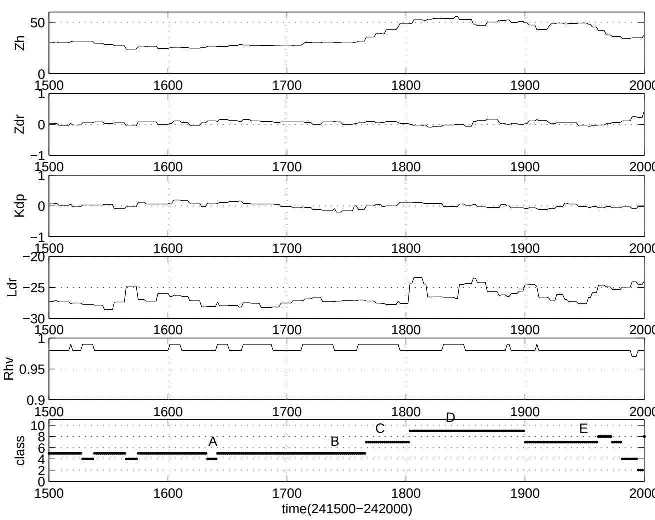

Fig. 5. Fuzzy hydrometeor classification results along the T-28 aircraft track. From ($x : -12.94$Km, $y : 16.37$Km) to ($x : 6.52$Km,$y : 36.80$Km) during the June 22,2000 storm

Km, y=24.47 Km), region D (x=-0.66 Km, y=27.38 Km), and region E (x=4.3 Km, y=33.8 Km) are aggregated snow, ice crystal, graupel and/or small hail, hail, graupel and/or small hail, respecively. By comparing the results , we can see fairly good agreement between classifier results and T-28 aircraft data (for each region A-E). In addition, region D classified as hail is in agreement with the hail counts from the hail spectrometer shown in Fig. 7(from 1802-1859), as well as HVPS images(not shown).

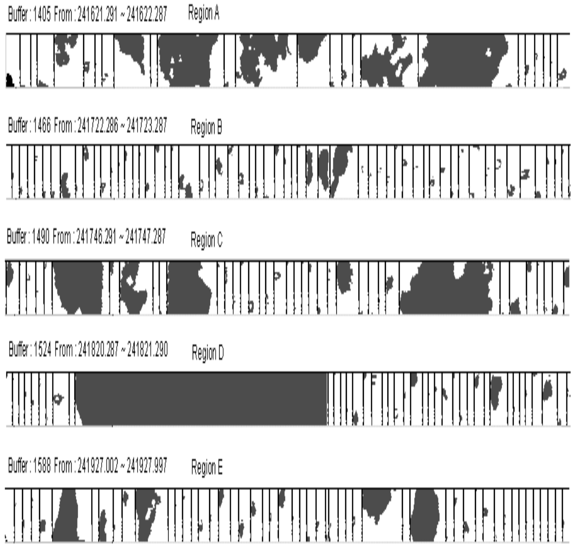

Fig. 6. T-28 aircraft 2DC image data

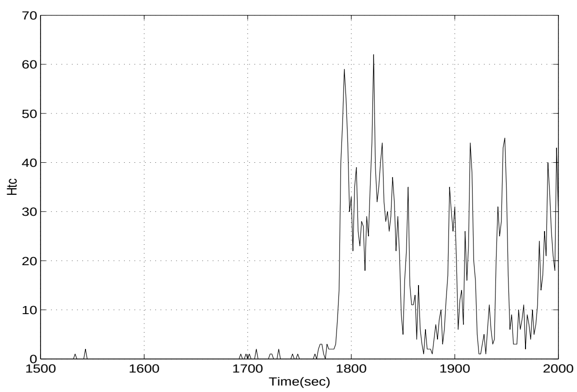

Fig. 7. Hail total count from hail spectrometer

4. SUMMARY AND CONCLUSION

In this paper, the hydrometeor classification result from CSU-CHILL observations during STEPS is compared against T-28 in-situ data. The result agrees very well with the T-28 data. This is ongoing research and we expect to improve the hydrometeor classification with extensive in-situ comparisons.

5. ACKNOWLEDGE

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